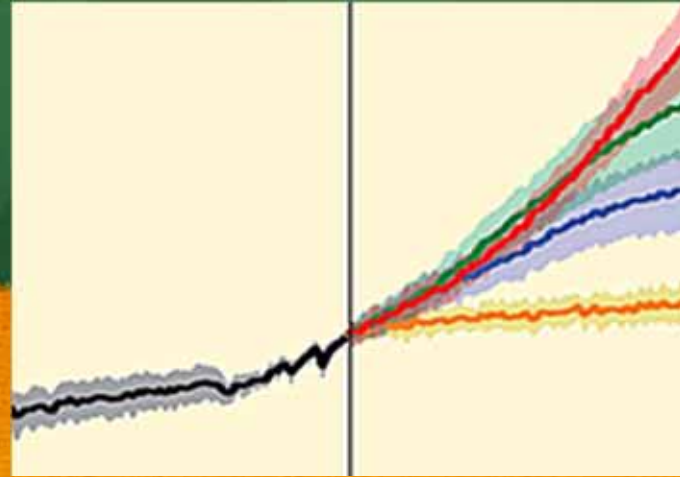




## **NASA/UCAR/NESTA: Predicting Future Climate and Considering Solutions**

**Presented by: Dr. Randy Russell**

**Thursday, October 28, 2010  
6:30 p.m. - 8:00 p.m. Eastern time**



# Predicting Future Climate and Considering Solutions

A web seminar for the NSTA community  
by the UCAR Office of Education and Outreach  
and NESTA with support from NASA.

# Overview

- What is a climate model?
- Future predictions of climate and the role of the IPCC
- Two online interactives:
  - *The Very, Very Simple Climate Model*
  - *Energy Choices and Climate Change*
- The path towards sustainability
  - *Watch Where You Step*, an activity from Facing the Future



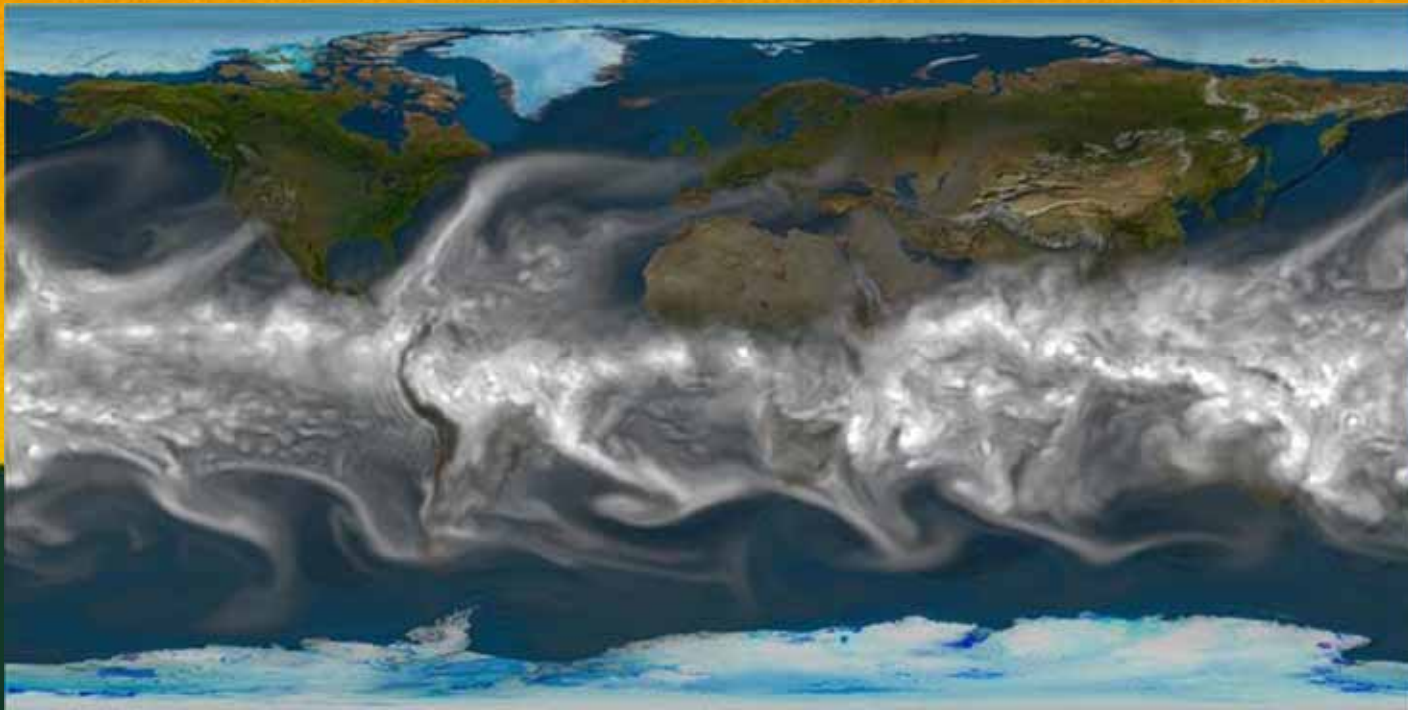
Presenter:  
**Dr. Randy Russell**  
Educational Designer  
UCAR Office of  
Education and Outreach







# What is a climate model?



# The Earth is a System



## Parts of the Earth System



Air



Water



Life



Land



Ice

- The **atmosphere** (air) extends from the Earth surface for several hundred km.
- The **hydrosphere** (water) includes the ocean, rivers, lakes, groundwater, vapor.
- The **biosphere** (life) includes bacteria, protists, plants, and animals.
- The **geosphere** (land) includes minerals, rocks, molten rock, sediments, soils.
- The **cryosphere** (ice) includes snow, glaciers, and sea ice.



# How does a climate model describe the Earth system?



- Global climate models use mathematical equations to describe the behavior of factors that impact climate.
- Factors include
  - Atmosphere
  - Ocean
  - Land surface
  - Living things
  - Sea ice
  - Solar radiation

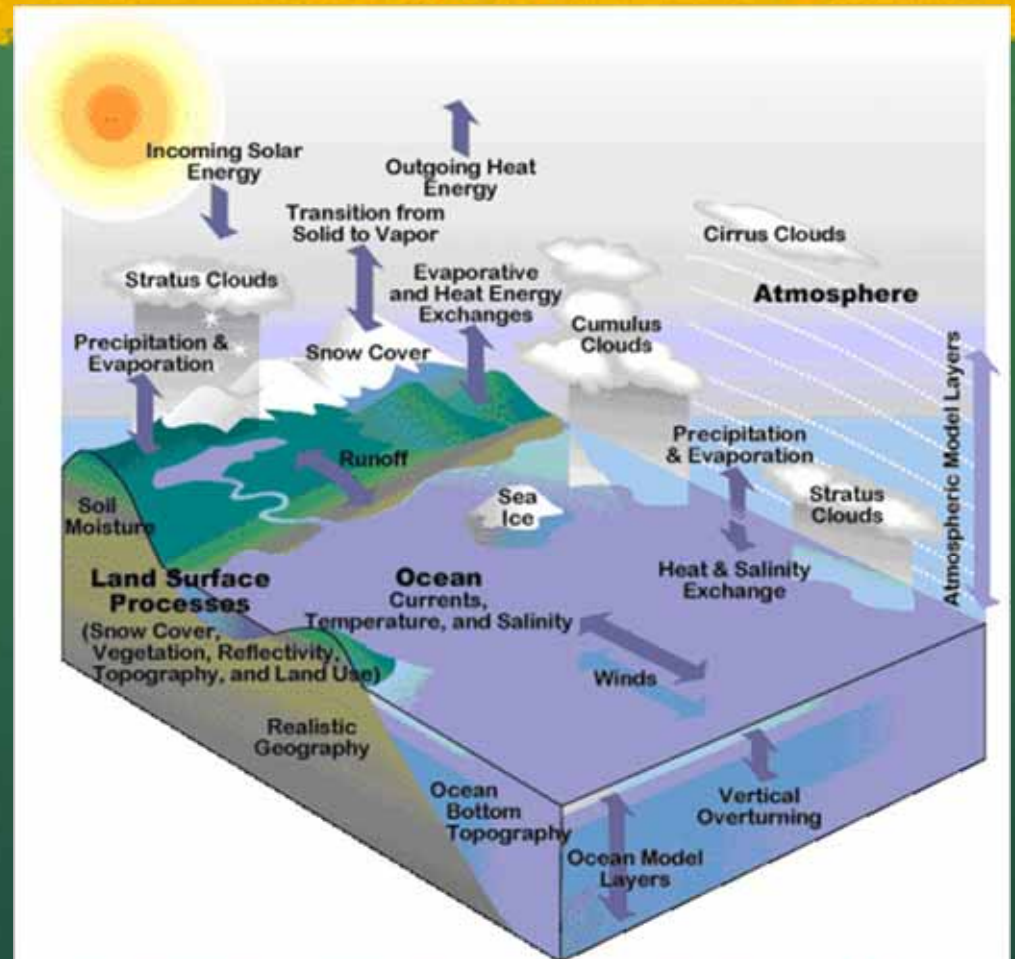
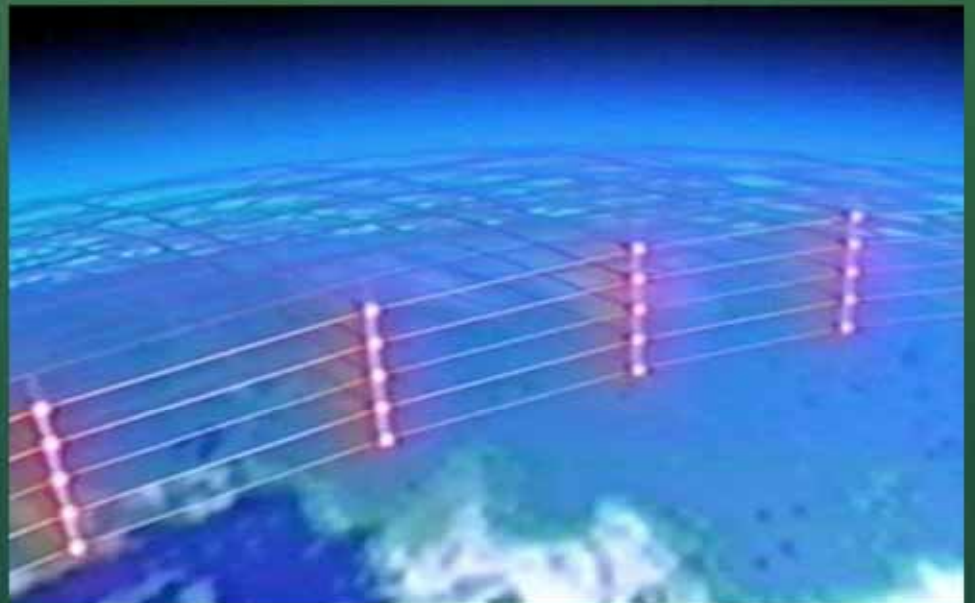
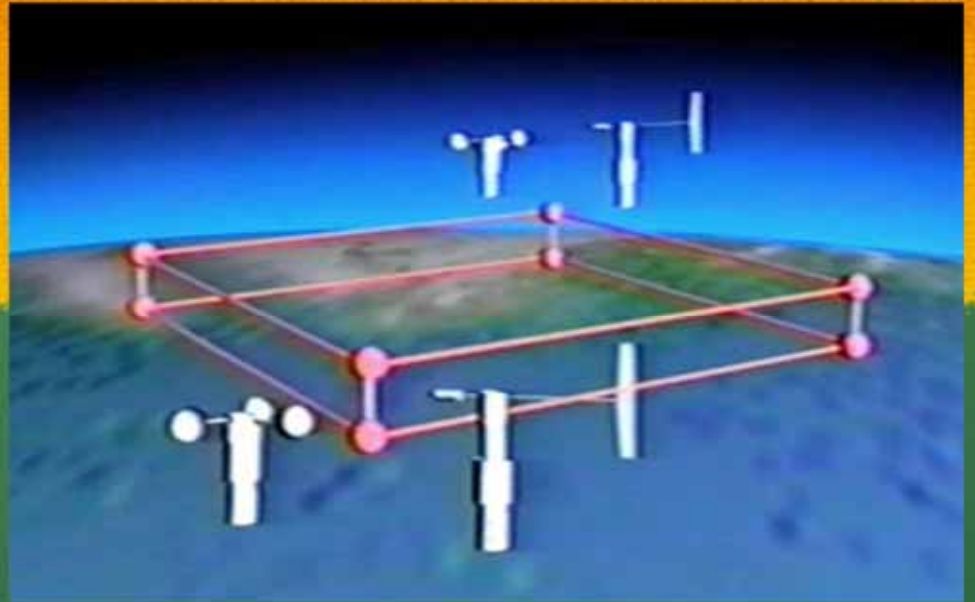


Figure 1. What types of information does a global climate model contain? The Community Climate System Model (CCSM version 3) that is run with NCAR's supercomputer incorporates data about the natural processes in the diagram above to simulate Earth's complex climate system. (image from UCAR)

# Climate Model Movie

Explains climate model grid



[http://eo.ucar.edu/staff/russell/climate/modeling/gcm\\_model\\_grid\\_video.html](http://eo.ucar.edu/staff/russell/climate/modeling/gcm_model_grid_video.html)



# Supercomputers: Then and Now



The Cray 1A (1970s) – a computer you could stand within!

It had computing power similar to a cell phone today.

NCAR Bluefire supercomputer has a peak speeds of more than 76 teraflops (76 trillion operations per second).



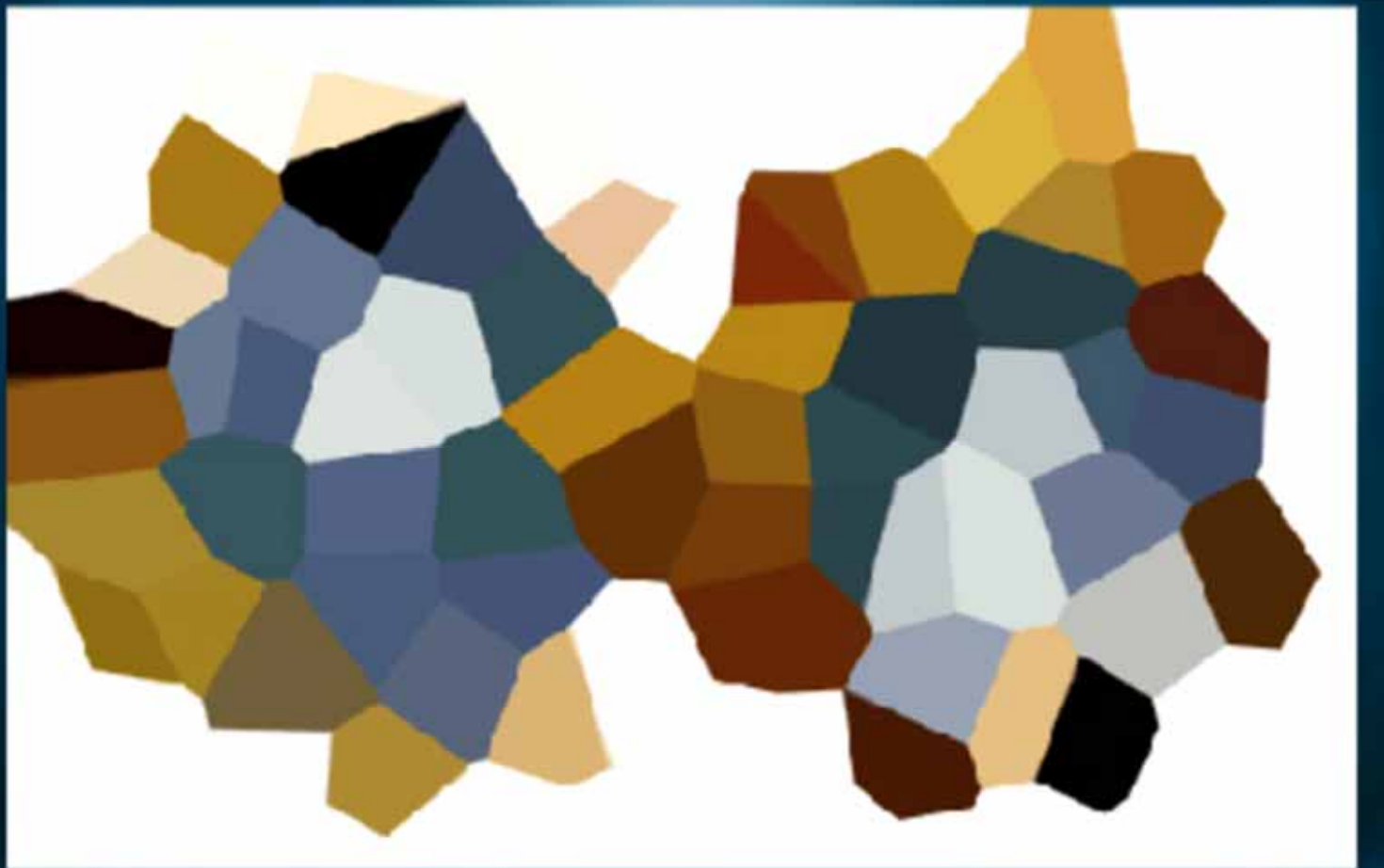


# Model resolution



- High resolution models are more detailed, and take tremendous computing time.
- Low resolution models are less detailed, and take less computing time.
- As super computers have become faster, climate models have gotten higher in resolution.

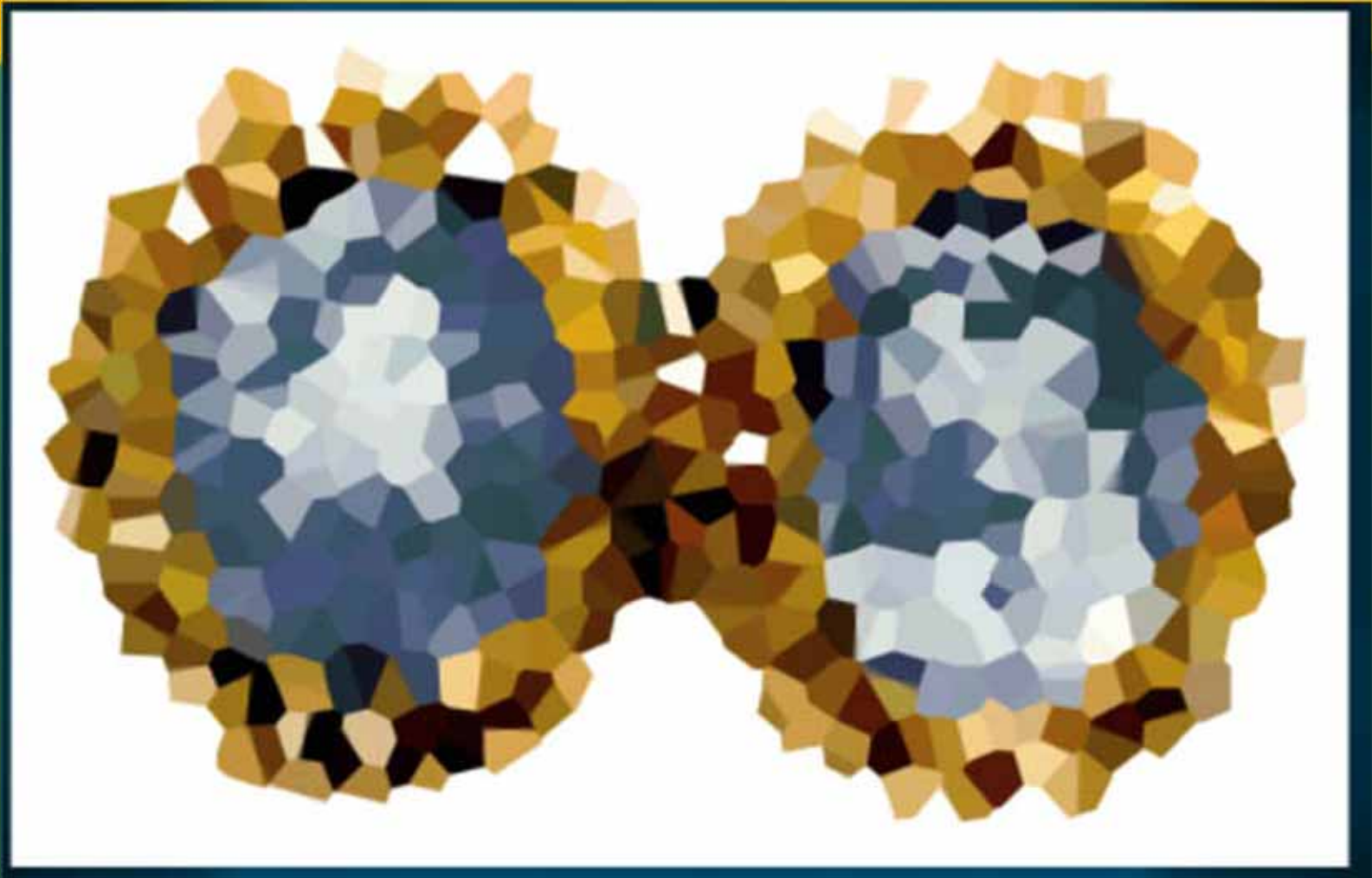
# What is this a picture of?



- Low resolution image



# Can you tell what this is now?



- Medium resolution image

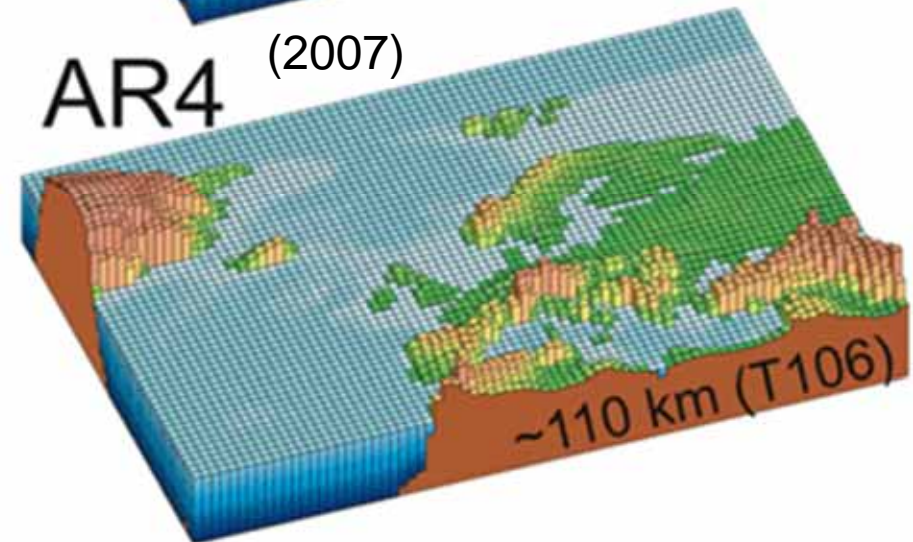
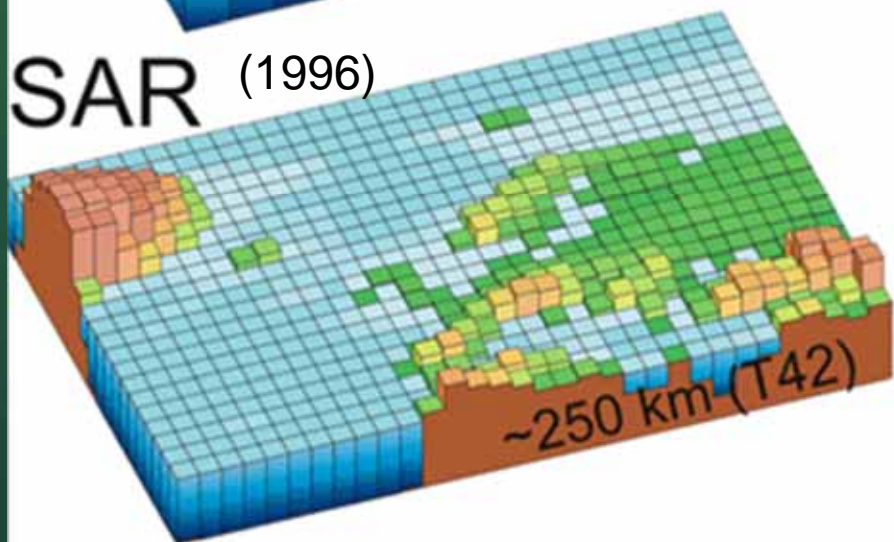
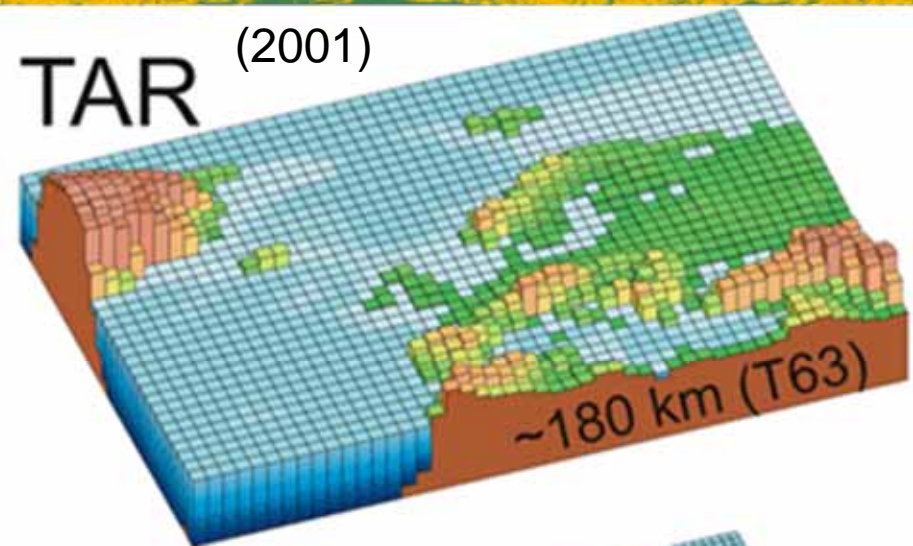
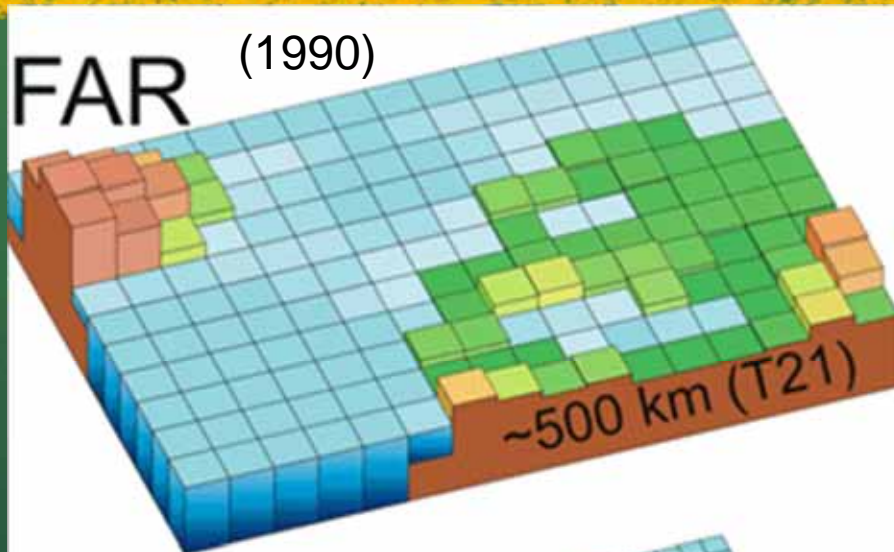
# How about now?



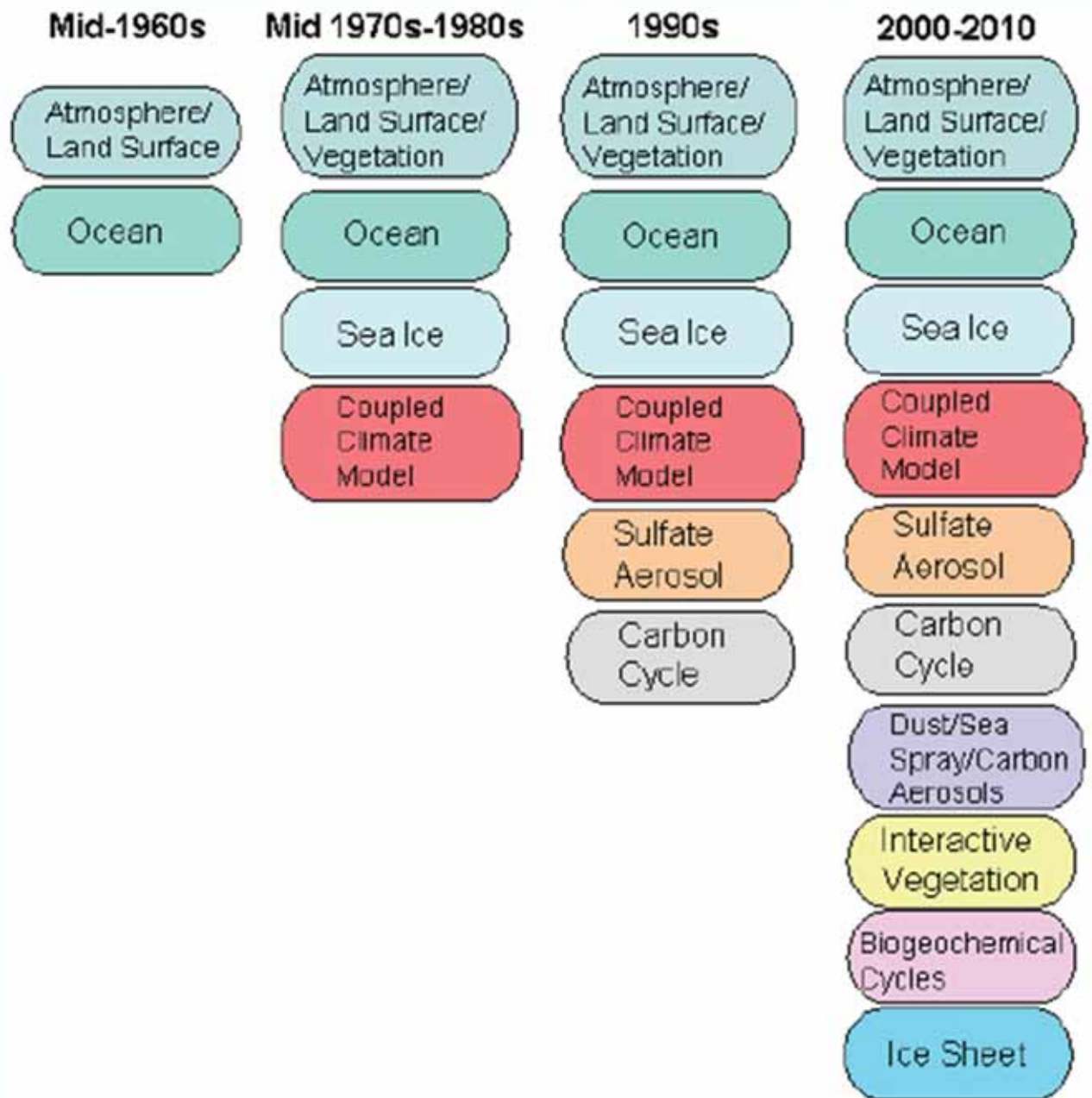
- High resolution image



# Climate model resolution has increased as computing speed has increased



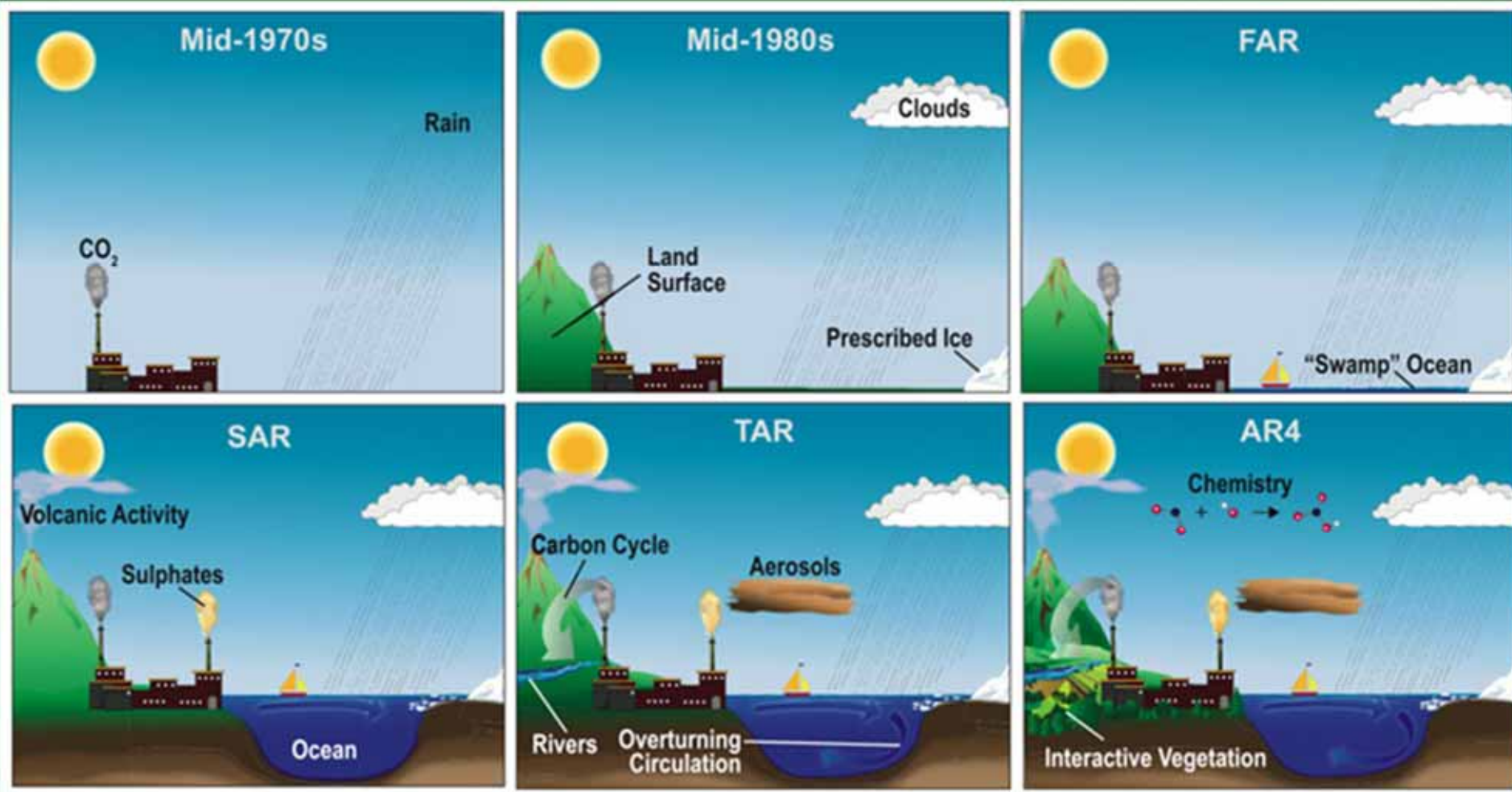
# Timeline of climate model development

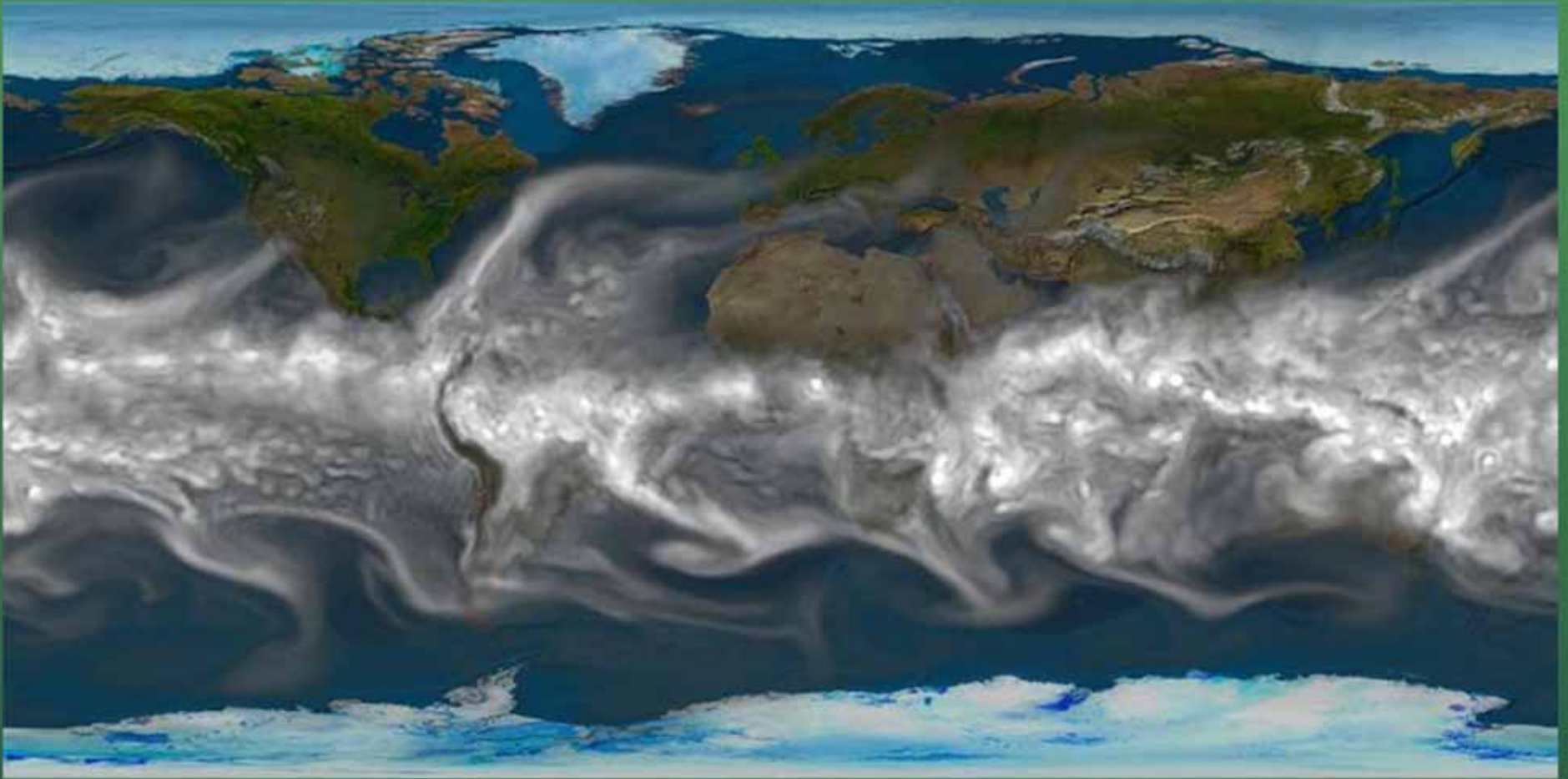




# Evolution of Climate Models

(graphic from IPCC AR4)





Example from a model of the Earth system:  
The distribution of water vapor in the atmosphere at one moment in time during a climate simulation by the NCAR-based Community Climate System Model (CCSM).

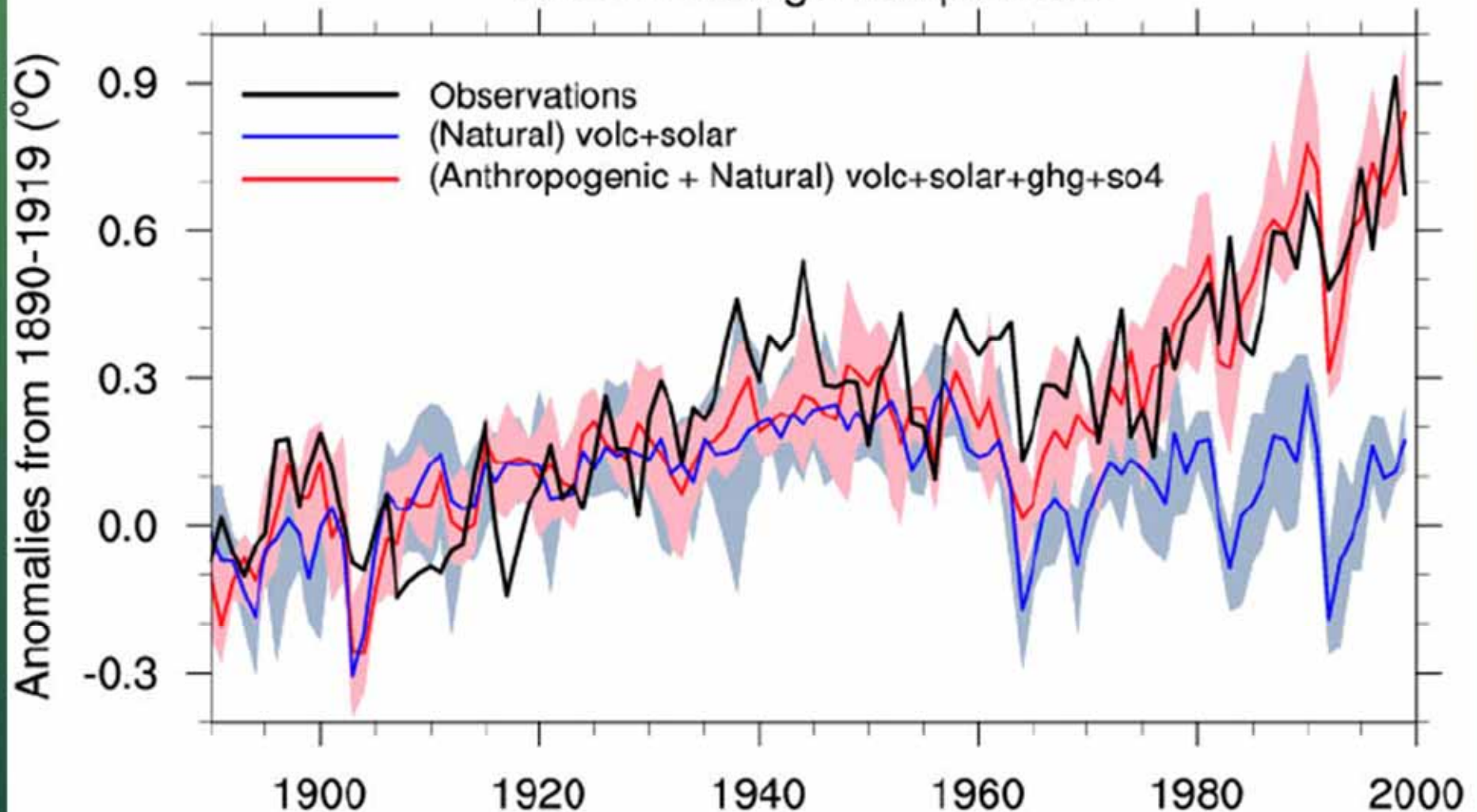
<http://www.vets.ucar.edu/vg/T341/index.shtml>





# ***Simulation of 20<sup>th</sup> Century Warming***

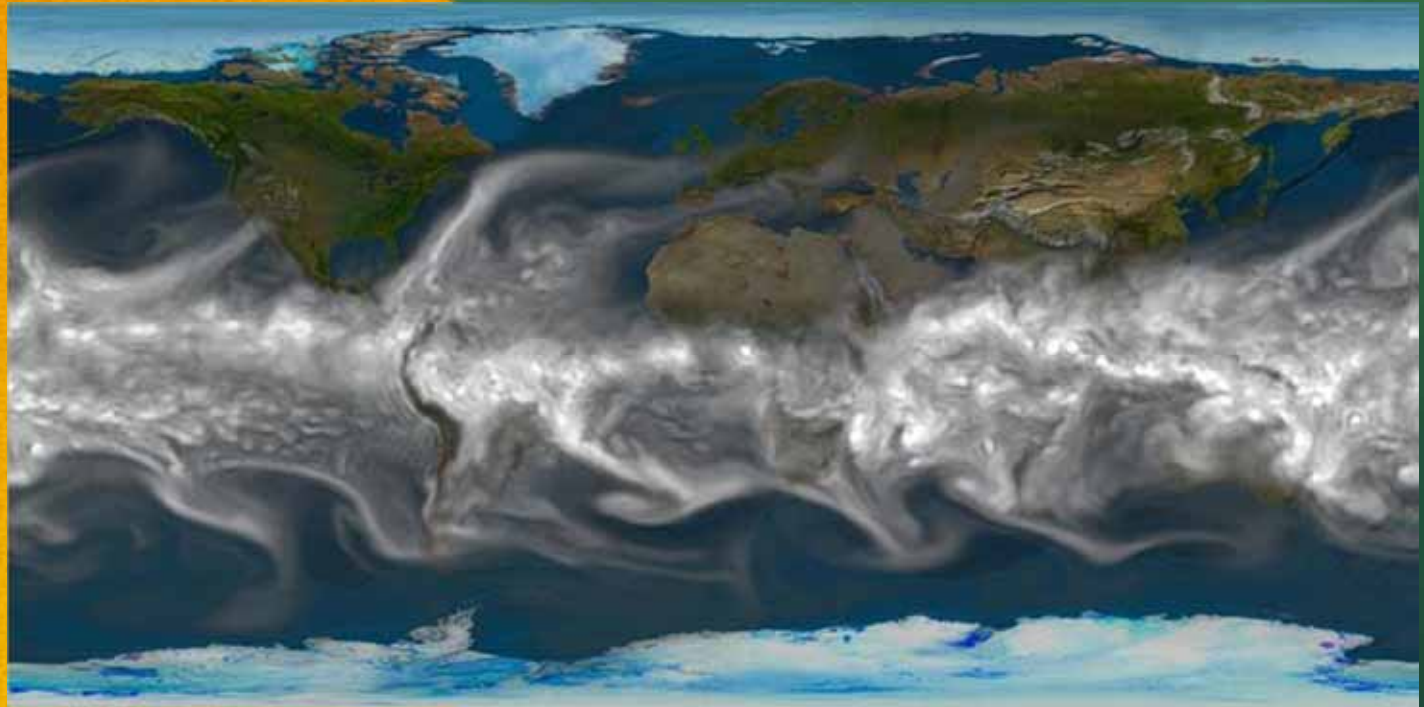
Global Average Temperature



(Image: Meehl et al., 2004)



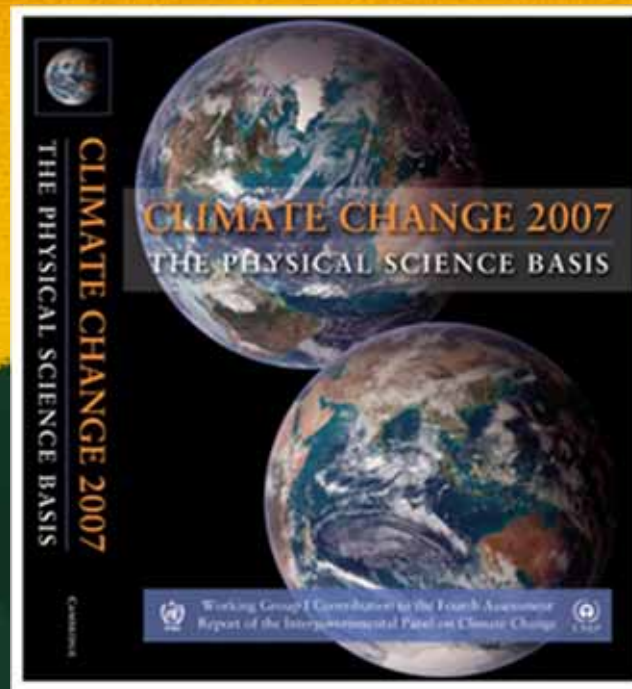
# Questions?





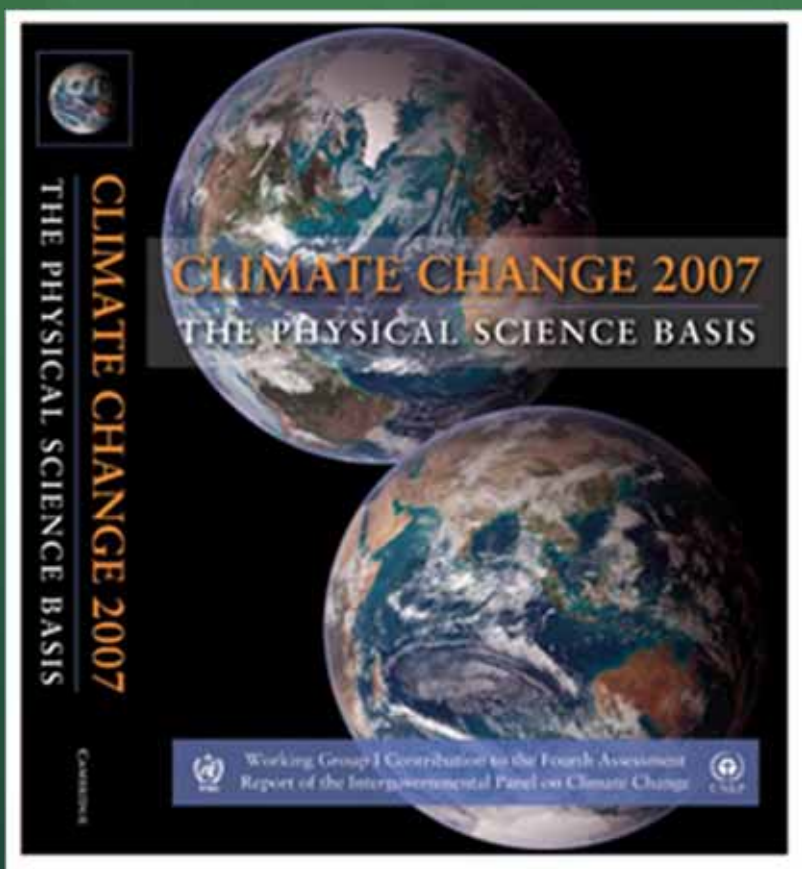


# Future predictions of climate and the role of the IPCC





# What is the Intergovernmental Panel on Climate Change?



- The IPCC, as it is known for short, is an international group that includes hundreds of climate scientists and government representatives.
- Every few years, IPCC scientists review our current state of understanding about climate: what we know and how certain we can be.

# In predicting future climate, the largest unknown is... us!

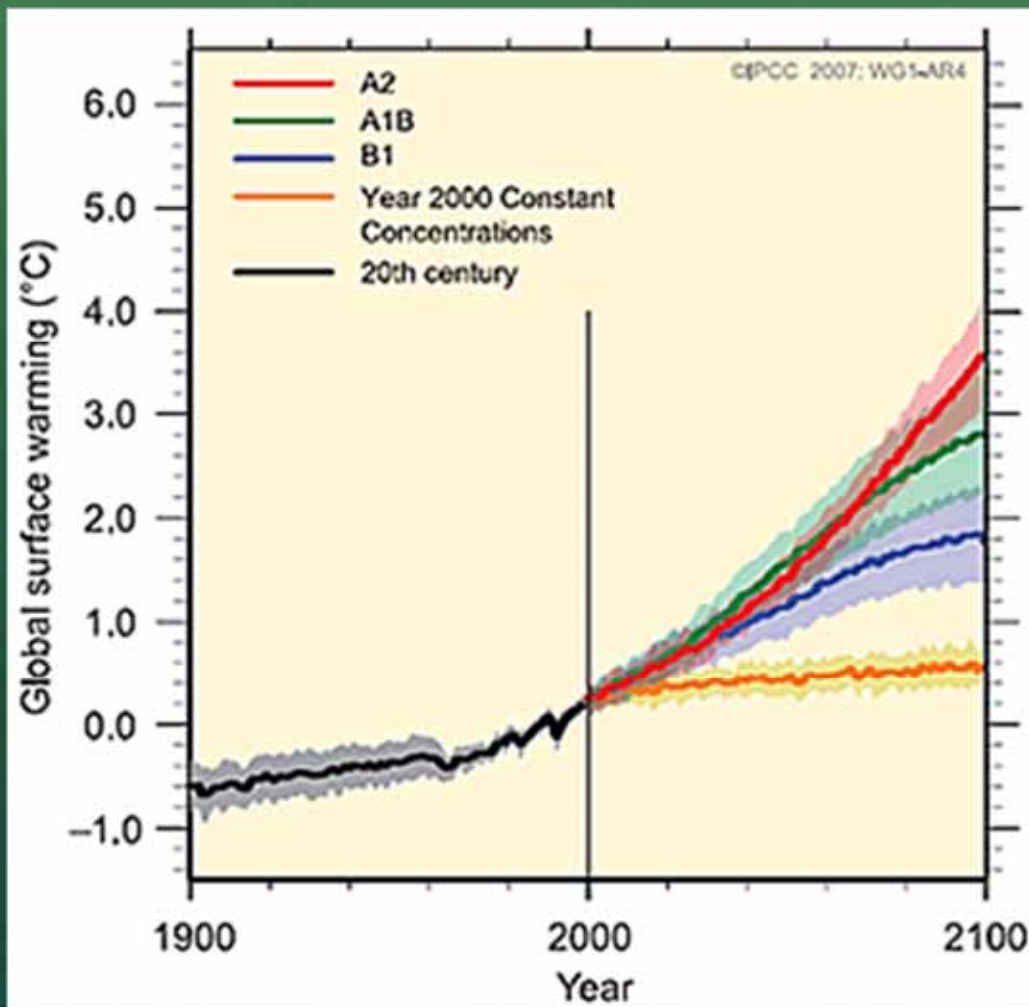


- **A1B:** Rapid growth of technology and economies, but population grows slowly. There is less disparity between developing and developed countries.
- **A2:** Economies grow but there is more disparity between developing and developed countries. Energy use is high and population is growing rapidly.
- **B1:** Development is sustainable, deforested land is planted with trees, human population grows slowly, and energy use is low.

	Economic growth	Population growth	Energy use
A1B	Rapid	Slow	Moderate
A2	Moderate	Fast	High
B1	Moderate	Very slow	Low



# Predictions of 21<sup>st</sup> Century Climate (according to the IPCC, 2007)



Temperature change as compared with 1980-1999 average, used as a baseline.

(The results of several climate models have been averaged in this graph.)

# Movie: Climate Model Visualization



[http://www.vets.ucar.edu/vg/IPCC\\_CCSM3/index.shtml](http://www.vets.ucar.edu/vg/IPCC_CCSM3/index.shtml)

(Climate Change Simulation by NCAR CCSM model, ~3 min)

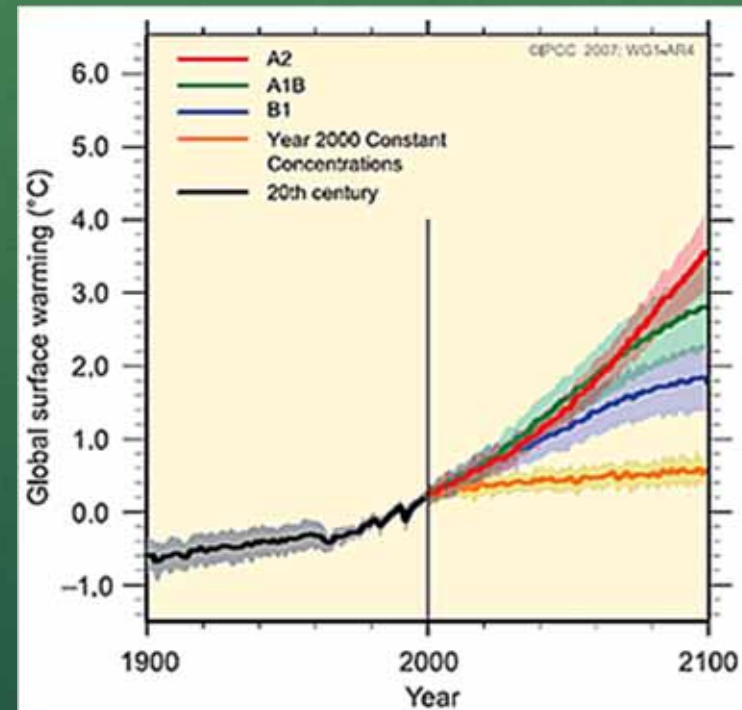
*What did you notice?*

- A. Volcanic eruptions effect climate for two generations.
- B. There is only one possibility for warming in the 21<sup>st</sup> C.
- C. Climate is going to get warmer according to this model .
- D. All areas of the planet will warm equally over time.





# Questions?





*The Very, Very Simple Climate Model*  
and  
*Energy Choices and Climate Change*  
- two online interactives -

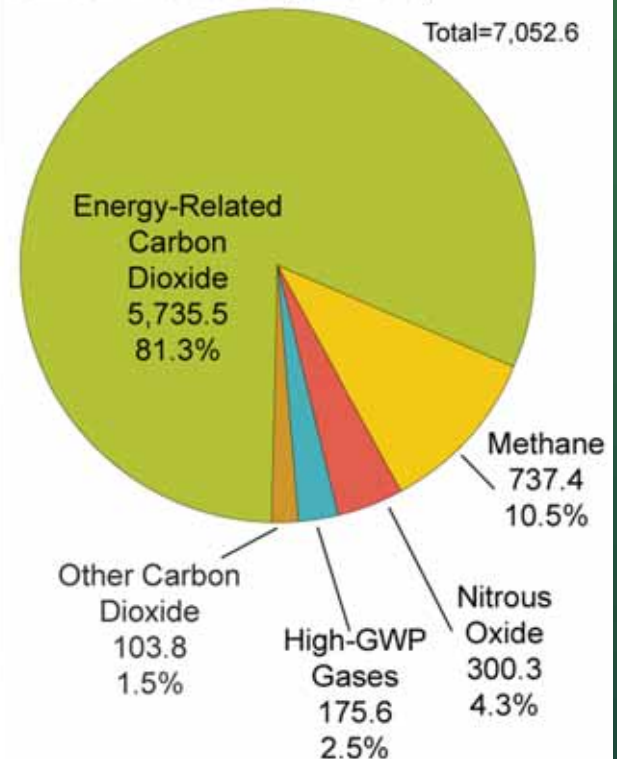


# The relationship between energy and greenhouse gases



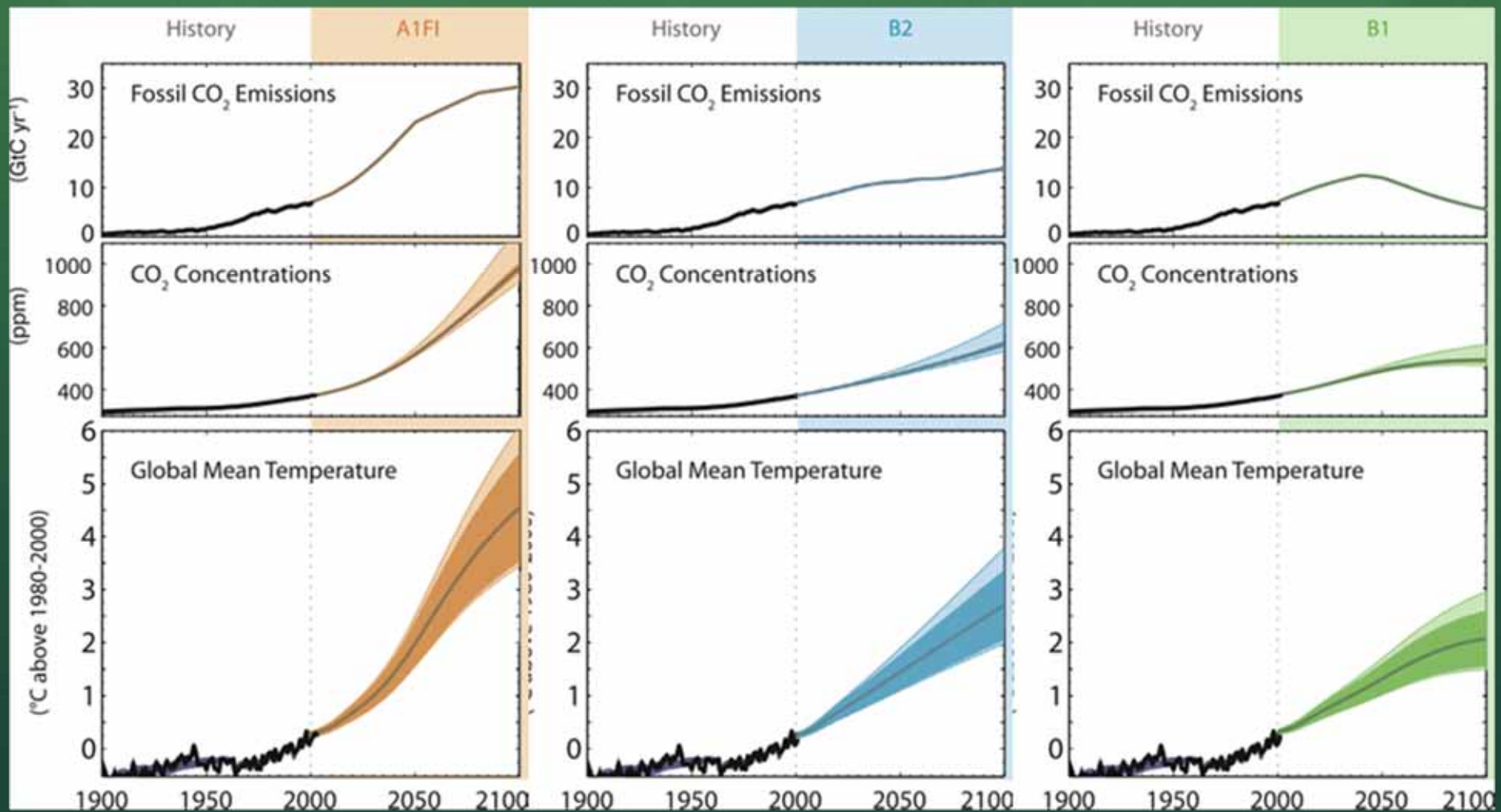
- Some sources of energy add greenhouse gases into the atmosphere. Others don't.
- Greenhouse gases emitted:
  - **Carbon dioxide and nitrous oxide** are released during fossil fuel combustion
  - **Methane** is released during coal mining and petroleum refining (as well as farming)

**U.S. Greenhouse Gas Emissions by Gas, 2008** (Million Metric Tons Carbon Dioxide Equivalent)



Source: EIA estimates, published in *Emissions of Greenhouse Gases in the United States 2008* (December 2009).

# CO<sub>2</sub> Emissions, Concentration, and Temperature





# Try it #1!

## The Very, Very Simple Climate Model

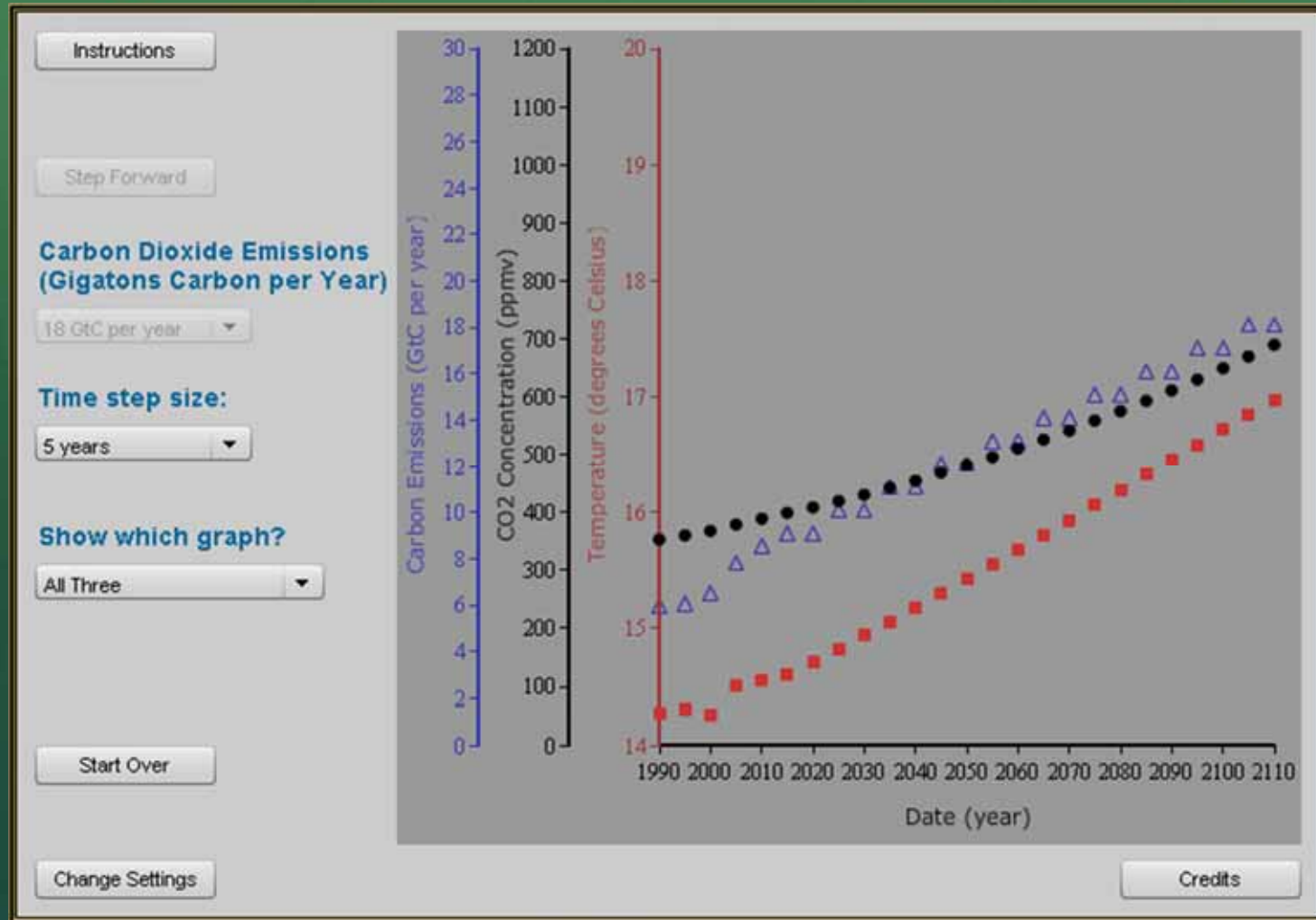


[http://www.windows2universe.org/earth/climate/cli\\_model.html](http://www.windows2universe.org/earth/climate/cli_model.html)

Directions:

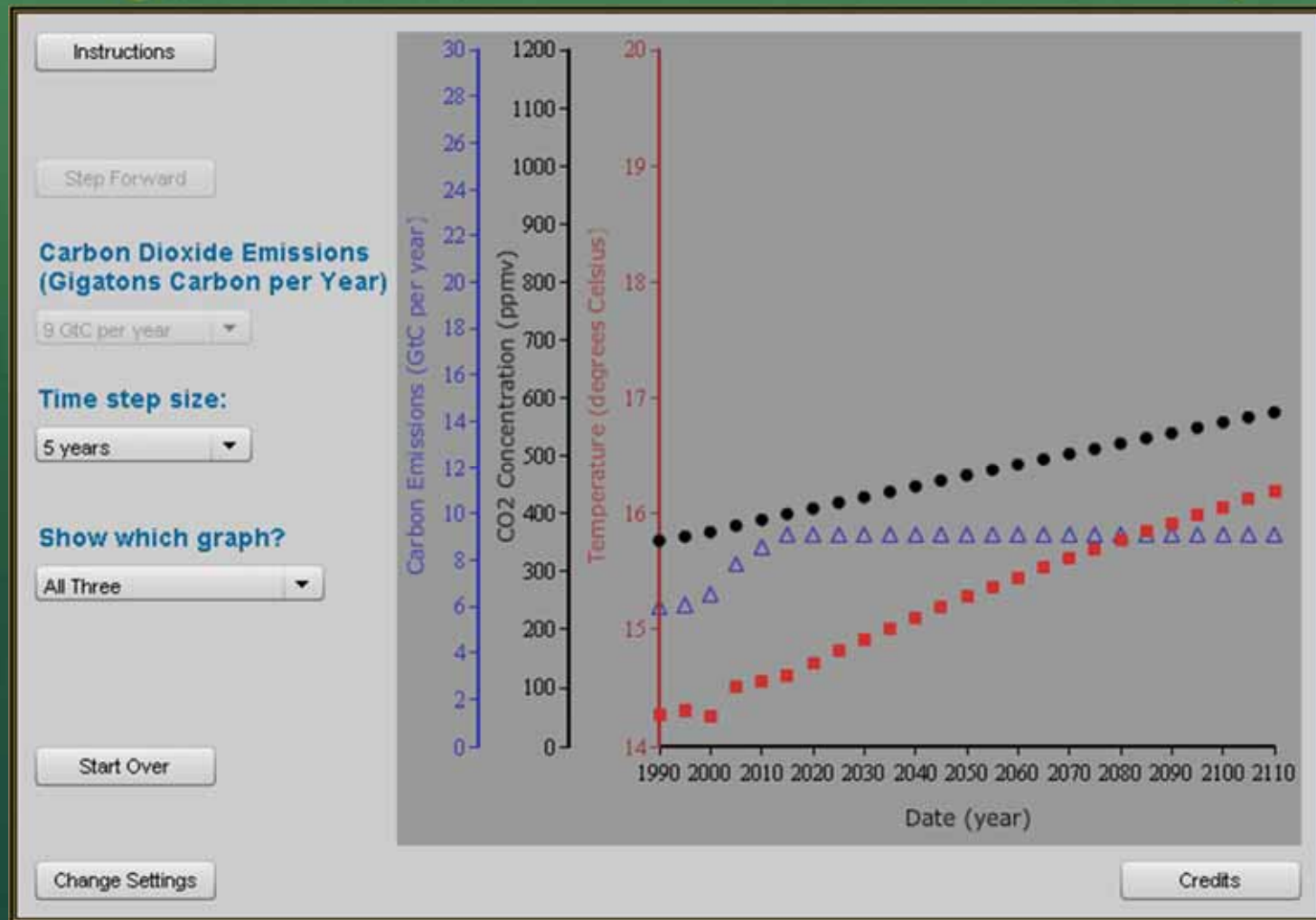
1. Set **CO<sub>2</sub> emissions rate**: Amount of CO<sub>2</sub> released per year
2. Set the **Timestep** depending on how far you want the model to jump ahead at each step.
3. Click “**Step Forward**” several times to see how temperature and CO<sub>2</sub> change over time.
4. Report the approximate CO<sub>2</sub> concentration and temperature your model shows for the year 2100 in the chat.

# Rising CO<sub>2</sub> Emissions

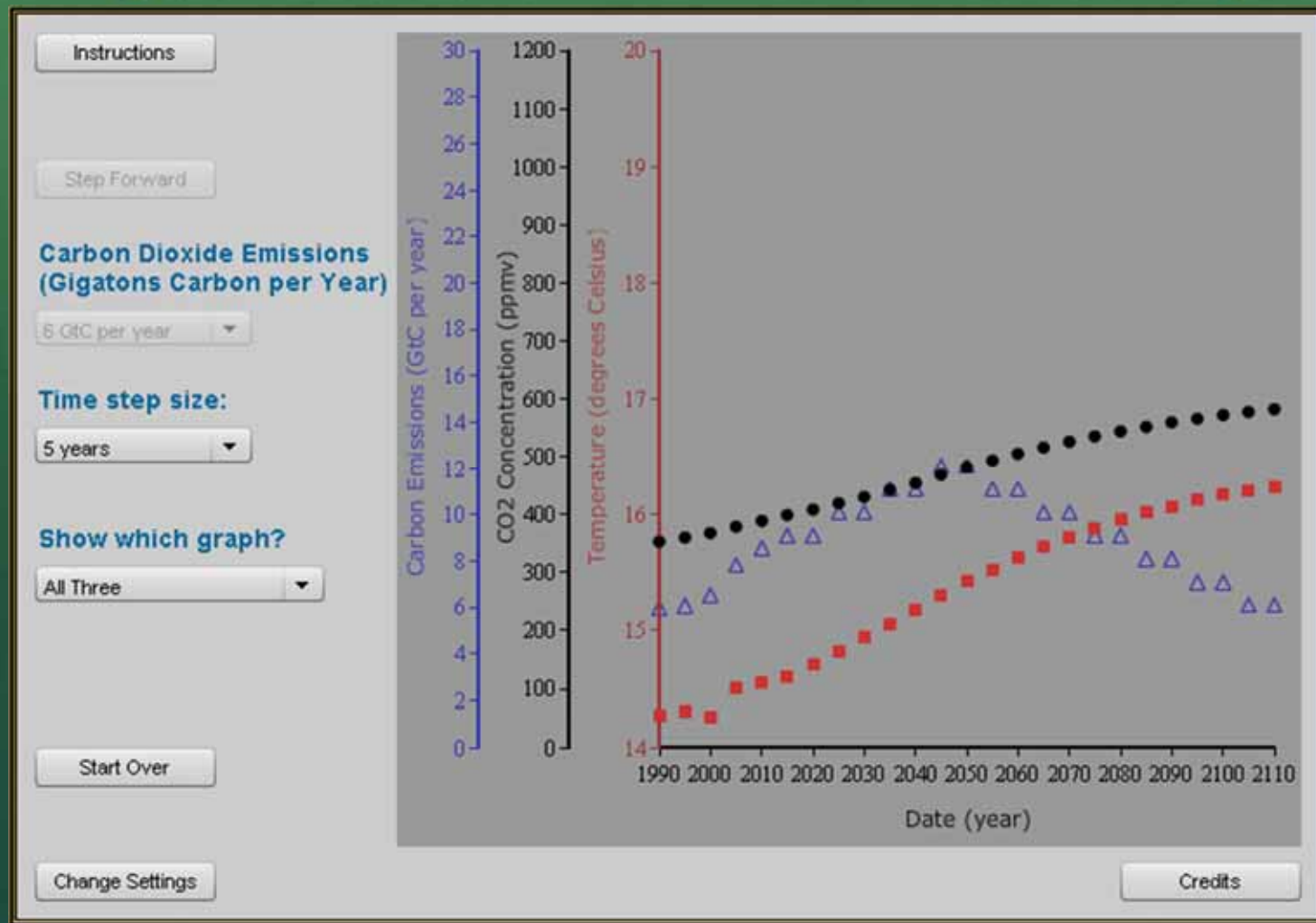




# Steady CO<sub>2</sub> Emissions

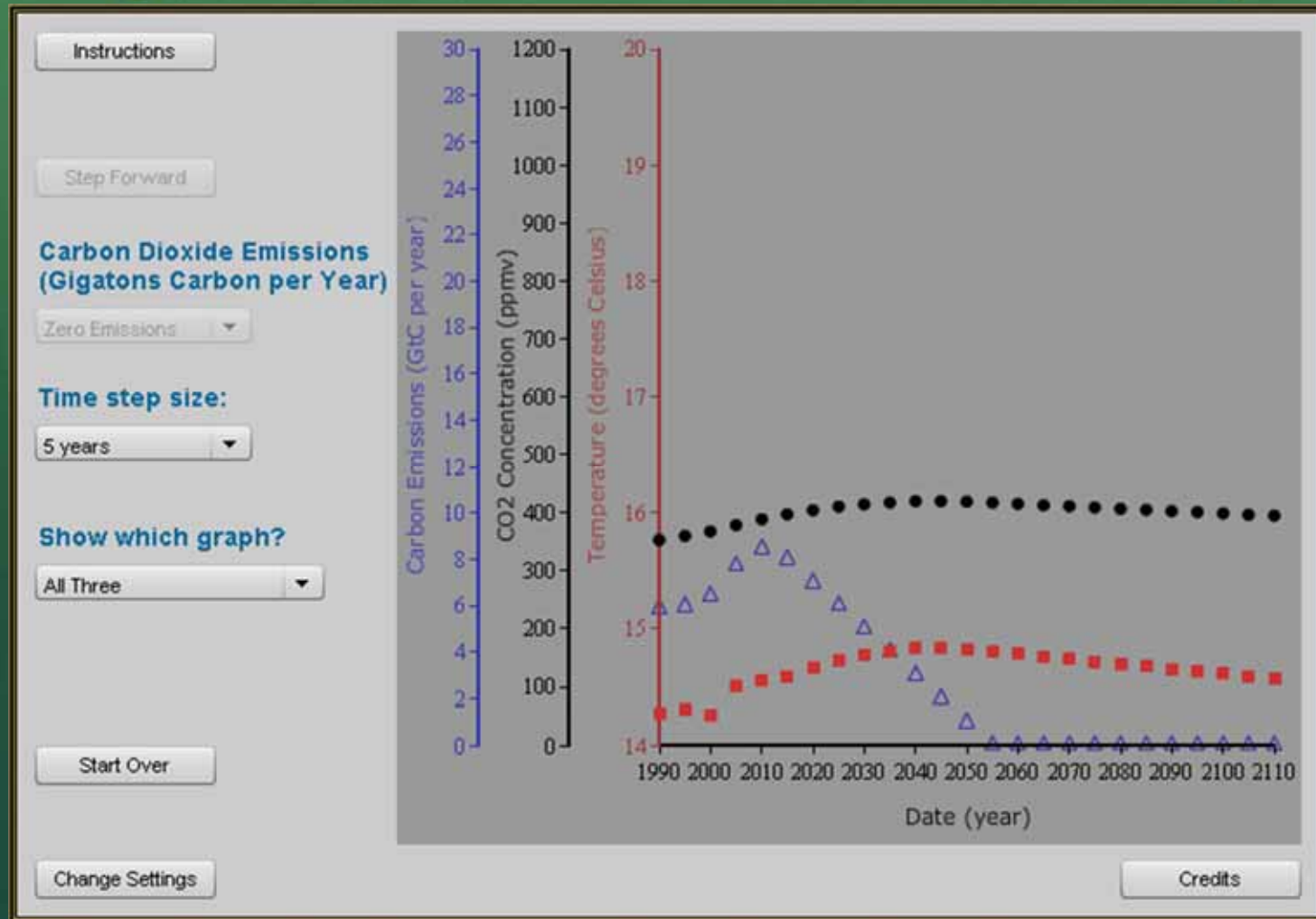


# CO<sub>2</sub> Emissions Rise... then Fall (after 2050)





# CO<sub>2</sub> Emissions Cut to Zero



# Energy sources that emit greenhouse gases when burned



- **Fossil fuels**

- Coal
- Petroleum (oil)
- Natural gas



- **Biofuels**

- *(however, biofuels are renewable and take  $CO_2$  out of the atmosphere when re-grown.)*





# Energy sources that do **not** emit greenhouse gases into the atmosphere



- Renewable energy
  - Wind
  - Solar
  - Waves/hydropower
  - Geothermal
- Non-renewable
  - Nuclear (creates other waste)



# Greenhouse gases trap heat.

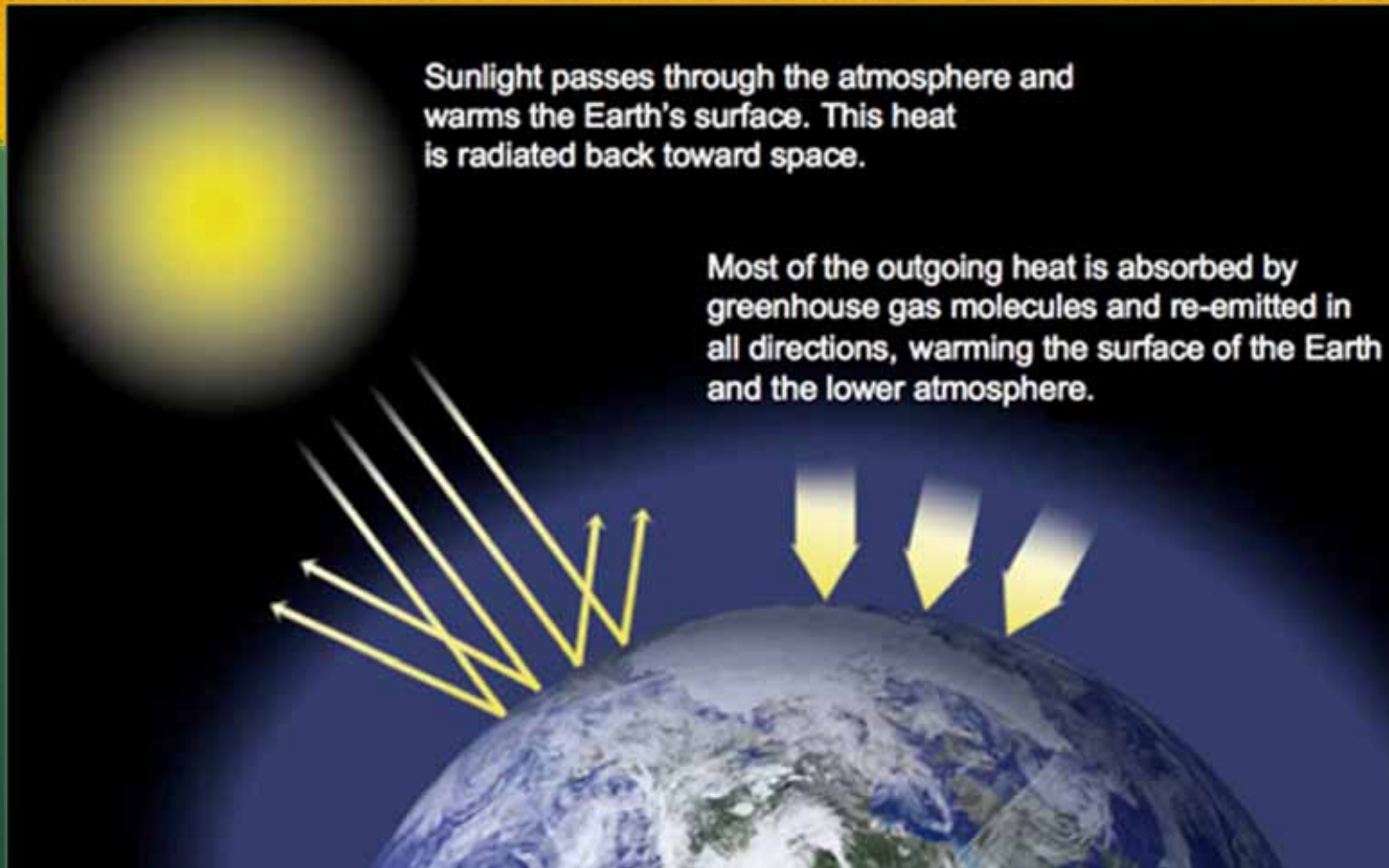


Image: NASA

- Greenhouse gases are a natural part of the atmosphere.
- The amount is now high due to emissions by humans.

# *Energy Choices and Climate Change* an online module from NCAR/UCAR



- In the module, you make decisions about the types and amount of energy used.
- See what effect decisions have on the amount of greenhouse gases emitted to the atmosphere.
- Goal: reduce the amount of greenhouse gases added to the atmosphere from fossil fuel emissions while keeping costs within reason.

<http://www.windows2universe.org/modules/energy/>




# Exploring the module

How do the choices we make about energy affect CO<sub>2</sub> emissions?

Dive into one of the two module scenarios to explore this question!






### The Joules Family

Get to know Forest, Kelly, Olive and Teal Joules. Help them make tough choices that conserve energy and keep greenhouse gases from getting into the atmosphere.

### Ruler of the World

As either king or queen of the world, make decisions about energy sources and change amount of greenhouse gases we send into the atmosphere each year.



[www.windows2universe/modules/energy](http://www.windows2universe/modules/energy)

## *Scenario: The Joules Family*



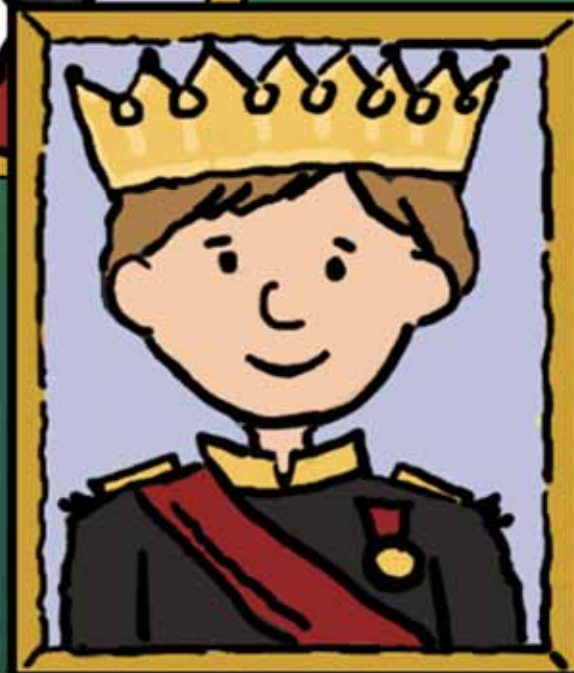
**Your goal:**  
Choose how to change the way a hypothetical family uses energy at home and for transportation with the aim of reducing the family's carbon dioxide emissions while keeping costs less than long-term savings.



# *Scenario: Ruler of the World*

## **Your goal:**

Make decisions about the mix of energy sources that will be used worldwide with the aim of reducing emissions and meeting global energy demand while monitoring costs and societal implications.





# Module Features



- **Scenario tabs:** Users click through tabs that describe a scenario and allow them to make choices about energy use.
- **Background information:** Additional information about energy can be found in the the accordion tabs at the right.
- **Dashboard:** Meters at the top of the screen show how choices affect GHG, money, energy use, and other factors.

The screenshot shows the 'Energy Choices and Climate Change' interface. At the top, it says 'Energy Choices and Climate Change' and 'NCAR'. Below this, there's a 'Dashboard' section with various meters and icons. A blue arrow points to the 'Dashboard' section with the text: 'DASHBOARD keeps track of how changes affect CO2 emissions and other factors'. Below the dashboard, there's a 'Tabs' section with a blue arrow pointing to it and the text: 'TABS click each tab to make changes to energy use or fuel type in each category.' The main content area is titled 'Food, Energy, and CO2' and contains a cartoon illustration of a family. To the right of the main content, there's a 'Background Information' section with a blue arrow pointing to it and the text: 'BACKGROUND INFORMATION learn more about energy by browsing the information under each blue heading'. The interface includes various interactive elements like dropdown menus and buttons.



## Try it #2: The Joules Family

- Head to the *house* tab and experiment by choosing different options from the drop down lists.
- Cast your vote: Which saves the most energy?
  - A. Turn down the heat
  - B. Insulate and seal gaps
  - C. Move to a smaller home





## Try it #3: The Joules Family

- Head to *transportation* and experiment by choosing different options from the drop down lists.
- Cast your vote: How can Kelly save the most gasoline?
  - A. Telecommute two days per week
  - B. Take the bus instead of driving
  - C. Carpool with a neighbor
  - D. Trade in the SUV for a more fuel efficient car







## Joules Family Results:

*How much CO<sub>2</sub> did you keep from the atmosphere?*

- Make choices in each category and then click “I’m Done”.
- Use the text tool and report the pounds of CO<sub>2</sub> above.



# Questions?





# The path towards sustainability: climate mitigation & adaptation

*(Watch Where You Step from Facing the Future)*



# What can we do?

- We can try to adapt to changing climate
  - **Adaptation:** protecting people/places by making them less vulnerable to climate impacts
- We can try to slow or stop warming
  - **Mitigation:** slowing global warming by lowering levels of greenhouse gases in the atmosphere



## Goal: keep Earth livable

**Sustainability:** meeting our present needs without compromising the ability of future generations to meet their needs



# Brainstorm Examples

**Adaptation**

**Mitigation**

Choose the textbox tool and write in an answer on this slide.

# Activity: Watch Where You Step

© *Facing the Future*



## First, Choose:

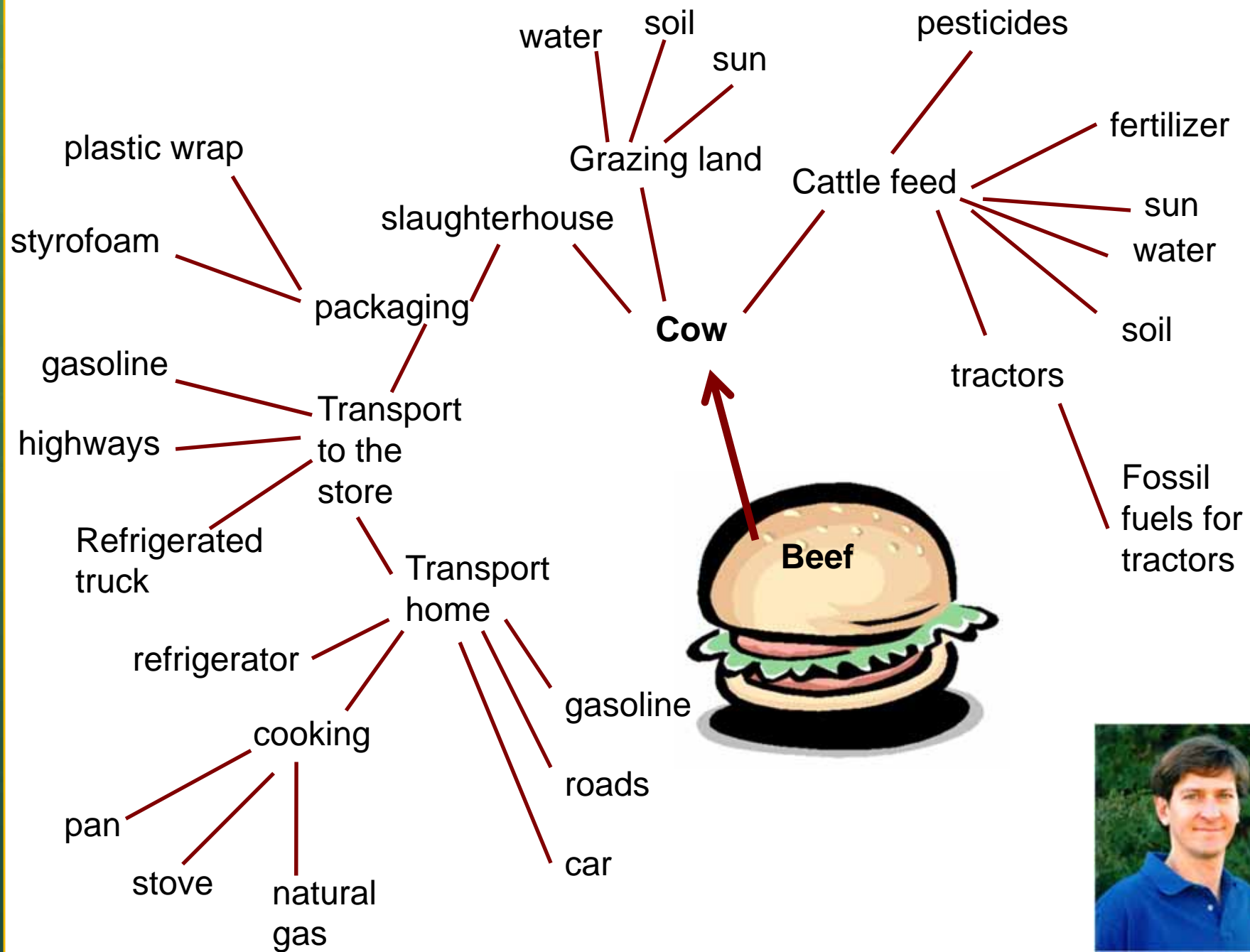
- A Favorite Meal
- A Favorite Object
- A Piece of Clothing
- A Mode of Transportation



## Then, Diagram:

- Resources needed
- Processes needed
- Impacts on the environment







# Questions?



# Climate and Global Change on Windows to the Universe

**WINDOWS TO THE UNIVERSE**  
*Brought to you by the National Earth Science Teachers Association*

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There are over 900 rings of stone located in the British Isles. The most famous of these stone rings is of course, [Stonehenge](#). The stones of Stonehenge were put in place between 3,000 B.C. and 2,000 B.C. by neolithic people. Some speculate that the site was built as a temple of worship of the ancient Earth deities. Some say it was used as an astronomical observatory of sorts. Still others say it was a burial ground.

*Image courtesy of Corel Photography.*

1 2 3 4 5 6



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Check out the "Events" section to learn about our free seminars, offered through NSTA Web Seminars this spring.

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**The Global Climate Change Educator Professional Development Network** Hello everyone! Register at the NSTA Learning Center for these free climate change web seminars this spring. And invite all your secondary science teacher friends to join us too!

March 12 at 3:50pm · Comment · Like

 2 people like this.

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**Web Seminar: Predicting Future Climate and Considering Solutions**  
Time: 5:30PM Wednesday, April 28th  
Location: (Time listed is Eastern Standard Time)

 March 12 at 3:41pm · Comment · Like · Share · RSVP to this event

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This series of web seminars, funded by NASA, is designed to bring climate and global change education resources to secondary...

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WINDOWS TO  
THE UNIVERSE



Randy Russell  
[rrussell@ucar.edu](mailto:rrussell@ucar.edu)

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